SB761
U7R6
#80-4

FOREST PEST MANAGEMENT

3430
BIOLOGICAL
EVALUATION R2-80-4

Distribution and Characteristics of Conifer Root Diseases on the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests in Colorado

APRIL 1980

United States Department of
Forest Service
Forest Pest Management
Denver, Colorado

3430
BIOLOGICAL
EVALUATION R2-80-4

Distribution and Characteristics of Conifer Root Diseases on the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests in Colorado

APRIL 1980

3430
BIOLOGICAL
EVALUATION R2-80-4

Distribution and Characteristics of Conifer Root Diseases on the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests in Colorado

APRIL 1980

PREPARED BY: Robert L. James

Robert L. James
Plant Pathologist

Donald J. Goheen
Plant Pathologist (Region 6)

APPROVED BY:

G. L. DOWNING
Staff Director
Forest Insect and Disease Management

LARRY D. HENSON
Deputy Regional Forester
State and Private Forestry

Forest Insect and Disease Management
State and Private Forestry
Rocky Mountain Region
USDA Forest Service
11177 W. 8th Avenue
Lakewood, Colorado 80225

ACKNOWLEDGEMENTS

Assistance of P. Donaldson and A. Wood with field data collection and laboratory analysis of root disease samples is appreciated. We thank Forest Service personnel responsible for the areas surveyed for their cooperation. Appreciation is extended to T. E. Hinds, M. E. Shoemaker, and D. W. Johnson for technical assistance and manuscript review.

ABSTRACT

Roadside surveys to characterize tree mortality were conducted on the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests of Colorado in 1979. Conifer mortality centers were investigated for presence of root disease and insect activity. Root diseases were verified on over 99% of 344 trees examined; more than 80% of the trees were infested by bark beetles or wood borers. Major root pathogens found included *Fomes annosus* and *Armillariella mellea*. Stumps were adjacent to most white fir infected with *F. annosus*; many *A. mellea*-infected subalpine fir were in uncut stands. A black root stain caused by *Verticicladiella* sp. was found on Douglas-fir. Major insects associated with mortality included *Scolytus ventralis*, *Dryocoetes confusus*, *Dendroctonus pseudotsugae*, *D. rufipennis*, and wood borers. Root diseases and bark beetles seem intimately associated with much of the conifer mortality in the National Forests surveyed.

INTRODUCTION

Root diseases influence management of forests throughout the West by contributing to tree mortality and significantly reducing growth. They also impact stands by reducing stocking and expected yields. Trees with root disease may become hazardous to visitors in recreation and other high-use areas (14) and may adversely affect scenic quality in travel-influence zones.

Root diseases and insects are intimately associated with tree mortality in many western forest ecosystems. Goheen and Cobb (*unpublished*) reported that ponderosa pine infected by *Ceratocystis wageneri* Goheen and Cobb (= *Verticicladiella wagenerii* Kendrick) were more prone to infestation by bark beetles (*Dendroctonus brevicomis* LeConte, *D. ponderosae* Hopkins, and *Ips* spp.) and buprestid wood borers in California. Only 3% of the non-diseased trees that they sampled were attacked by bark beetles. Hertert, et al. (6) found that in Idaho 96% of the grand fir infested by bark beetles (mostly *S. ventralis* and *Pityokteines elegans* Swaine) also had root disease. A similar study (20) indicated that 98% of beetle-attacked grand fir examined in Idaho were root-diseased. Almost 86% of true fir recently infested by *S. ventralis* in Oregon and Washington had advanced root disease caused primarily by *A. mellea* and *Phellinus (Poria) weirii* (Murr.) Gilb. (17). Other significant associations between bark beetle infestations and root disease incidence were reported for white fir killed by a *S. ventralis* - *F. annosus* complex in California (2) and Douglas-fir, grand fir, and ponderosa pine infested by numerous bark beetle species and infected by *A. mellea* and *Polyporus schweinitzii* Fr. (22).

Little is known about the causes, distribution, and impact of root diseases in the Rocky Mountain Region, consequently emphasis has been placed on surveys to elucidate the current and potential role of such diseases on National Forest management within the Region. As part of these efforts, roadside surveys were done to locate and document root disease-associated tree mortality within portions of the San Isabel, Rio Grande, San Juan, and Grand Mesa National Forests in Colorado.

MATERIALS AND METHODS

Reconnaissance was conducted along selected roads within National Forest boundaries and areas of tree mortality were noted on standard forest maps (½" = 1 mile). Mixed-conifer and spruce-fir forest types were examined because past experience (9, 11) indicated that root diseases might be important in these stands No statistical sampling scheme was employed; non-random selection of tree mortality centers was made on the basis of accessibility and occurrence within National Forest lands. Not all mortality centers were investigated; however, a sufficient number

were sampled to give an overview of root disease-associated tree mortality. Areas of concentrated insect activity, such as mountain pine beetle infestations, were excluded from the survey.

The number of dead and dying trees over 1.4 m (4.5 ft) in height were tallied in each center sampled. Dead and live trees with reduced needle complement or chlorotic foliage were examined for typical signs of root disease such as mycelial fans, rhizomorphs, black stain, sporophores, and resin streaking. Root collar wood samples were collected for isolation of pathogens when identification could not be made in the field.

All trees examined for root diseases were classified by crown symptoms.[1/] Diameter (DBH), height, and crown class (dominant, codominant, intermediate, or suppressed) were also recorded. Each tree was then examined for evidence of insect activity, especially that of bark beetles and wood borers. Insect identification was based on gallery patterns and characteristics of collected adults. Other data taken at each mortality center included legal description of site, tree species, other diseases, and presence of and proximity to stumps.

RESULTS

Over 764 km (475 miles) of roadside conifer stands were surveyed within the four National Forests in Colorado. Road descriptions and approximate mileage surveyed are summarized in the Appendix. Most mortality centers consisted of white fir (*Abies concolor* (Gord. & Glend.) Lindl.) (Fig. 1, Table 1) and subalpine fir (*A. lasiocarpa* (Hook.) Nutt.) (Fig. 2, Table 2). Other species sampled included Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Mayr.) Sudw.) and Engelmann spruce (*Picea engelmanni* Parry) (Table 3). A total of 344 trees within 128 mortality centers were examined. Only 24 trees (7.0%) were alive; there were about 2.7 trees per mortality center.

Major root pathogens associated with tree mortality included *Fomes annosus* (Fr.) Cke. and *Armillariella mellea* (Vahl. ex Fr.) Karst. *Fomes annosus* was most common on white fir; however, it was also found on subalpine fir on the San Isabel National Forest (Table 2). *Armillariella mellea*

1/ Crown classification:

Green - majority of crown is healthy and lacks foliar discoloration.
Yellow - most of crown is chlorotic and thin, giving an overall yellow appearance.
Brown - tree recently dead; most foliage remains attached to twigs and branches.
Black - tree dead; lacks foliage.

was found on all conifer species. More than 7% of the white fir trees surveyed contained both pathogens (Table 1). A species of *Verticicladiella* (Fig. 3) was associated with Douglas-fir mortality on the San Juan National Forest. All pathogens were most easily identified on recently-killed trees. Only two (0.6%) of the sampled trees had no detectable root disease.

Over 80% of the trees sampled were infested by insects (Tables 1-3). The fir engraver (*Scolytus ventralis* LeConte) was most often associated with root-diseased white fir and the western balsam bark beetle (*Dryocoetes confusus* Swaine) often infested dying subalpine fir. The Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) was found on most Douglas-fir and the spruce beetle (*Dendroctonus rufipennis* (Kirby) was found on all Engelmann spruce sampled. Wood borers (Buprestidae and Cerambycidae) were occasionally found on most species.

The Indian paint fungus (*Echinodontium tinctorium* (E. & E.) E. & E.) and fir broom rust (*Melampsorella caryophyllacearum* Schroet.) were found on 1% and 13% of the root diseased white fir, respectively. Fir broom rust was especially common on the San Juan National Forest.

Stumps were located in more than half the mortality centers (Tables 1-3). Over 77% of the white fir mortality centers contained stumps. However, stumps were in only 37% of the subalpine fir centers.

DISCUSSION

Our survey confirmed the close association of bark beetles and wood borers with incidence of root disease. Over 80% of the root-diseased white fir, subalpine fir, Douglas-fir, and Engelmann spruce sampled were also infested by beetles. Only two beetle-infested trees (both subalpine fir) were without apparent root disease. [2/] Much conifer mortality appears to be the result of complex processes involving both root pathogens and insects. Our evidence and that of others (2, 6, 17) suggest that pathogens initially invade trees and predispose them to insects.

Fomes annosus was first reported in Colorado in 1931 on Engelmann spruce (25). The fungus has recently been found to be common on white fir within the State (9, 10). *Fomes annosus* has also been reported in the Intermountain (26), Northern Rocky Mountain (28), and Southwest (19) Regions on pine and true fir. It was most common on white fir in our survey. However, it also was found on subalpine fir within the San

---

2/ Because the sampling technique for root disease was restricted to root collar examination, disease on smaller roots might have been overlooked.

Figure 1. White fir mortaltiy center on the Rio Grande National Forest. Trees were infected with *Fomes annosus* and attached by *Scolytus ventralis*.

Figure 2. Subalpine fir mortality center on the San Juan National Forest. Dying trees were infected with *Armillariella mellea* and attacked by *Dryocoetes confusus*.

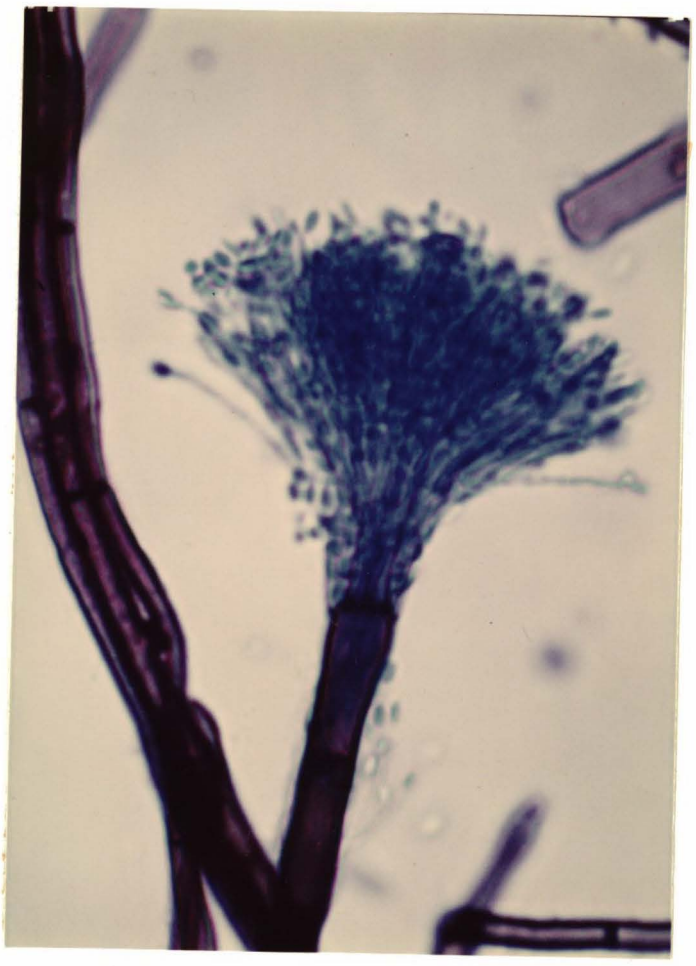

Figure 3. Conidiophore and conidia of *Verticicladiella* sp. associated with Douglas-fir mortality on the San Juan National Forest (X 450).

TABLE 1. Characteristics of white fir mortality centers on the San Isabel and San Juan National Forests of Colorado.

National Forest	Number of Mortality Centers	Number of Live Trees	Number of Dead Trees	Trees per Center	Root Pathogens [1]			Associated Insects [2]		Insects and Pathogens [3]	Centers Assoc. with stumps (Percent)
					Fomes annosus	*Armillariella mellea*	Both Fungi	*Scolytus ventralis*	Borers		
San Isabel	38	12	104	3.0	70.7	24.1	5.2	71.5	0.8	72.4	89.5
San Juan	24	0	49	2.0	32.6	55.1	12.3	98.0	2.0	100.0	58.3
TOTALS	62	12	153	2.7	59.4	33.3	7.3	79.4	1.2	80.6	77.4

[1] Percent of trees infected by root fungi.

[2] Percent of trees infested by bark beetles and borers.

[3] Percent of trees infected by root fungi and infested by insects.

TABLE 2. Characteristics of subalpine fir mortality centers on the San Isabel, San Juan, Rio Grande and Grand Mesa National Forests of Colorado.

National Forest	Number of Mortality Centers	Number of Live Trees	Number of Dead Trees	Trees per Center	Root Pathogens [1]			Associated Insects [2]			Insects and Pathogens [3]	Centers Assoc. with stumps (Percent)
					Fomes annosus	*Armillariella mellea*	Fungi	*Scolytus ventralis*	*Dryocoetes confusus*	Borers		
San Isabel	6	2	23	4.2	21.7	78.3	0.0	0.0	76.0	0.0	82.6	50.0
San Juan	18	4	28	1.8	0.0	93.8	0.0	0.0	81.3	18.8	100.0	33.3
Rio Grande	28	4	63	2.4	0.0	100.0	0.0	0.0	67.2	8.9	92.5	35.7
Grand Mesa	5	1	36	7.4	0.0	100.0	0.0	5.4	62.2	0.0	67.6	40.0
TOTAL	57	11	150	2.8	3.1	95.6	0.0	1.2	70.2	7.4	86.8	36.8

1/ Percent of trees infected by root fungi.

2/ Percent of trees infested by bark beetles and borers.

3/ Percent of trees infected by root fungi and infested by insects.

TABLE 3. Characteristics of Douglas-fir and Engelmann spruce mortality centers on the San Isabel, San Juan, and Rio Grande National Forests in Colorado.

Species	National Forest	Number of Mortality Centers	Number of Live Trees	Number of Dead Trees	Trees per Center	Root Pathogens [1]		Associated Insects [2]			Insects and Pathogens [3]	Centers Assoc. with stumps (Percent)
						Armillariella mellea	*Verticicladiella* sp.	*Dendroctonus pseudotsugae*	*Dendroctonus refipennis*	Borers		
Douglas-fir	San Isabel	6	1	14	2.5	100.0	0.0	53.3	0.0	26.7	80.0	66.7
	San Juan	1	0	1	1.0	0.0	100.0	100.0	0.0	0.0	100.0	0.0
	TOTAL	7	1	15	2.3	93.8	6.2	56.3	0.0	25.0	81.3	57.1
Engelmann spruce	San Isabel and Rio Grande	2	0	2	1.5	100.0	0.0	0.0	100.0	0.0	100.0	100.0

1/ Percent of trees infected by root fungi.

2/ Percent of trees infested by bark beetles and borers.

3/ Percent of trees infected by root fungi and infested by insects.

Isabel National Forest. Apparently, *F. annosus* is widely distributed and relatively important throughout the West.

The most widely distributed root pathogen in the Region is probably *A. mellea*. It has previously been reported on the following Rocky Mountain tree species: subalpine fir (8), lodgepole pine (*Pinus contorta* Dougl.) (11, 13), ponderosa pine (27), pinyon (*P. edulis* Engelm.) (16), Rocky Mountain juniper (*Juniperus scopulorum* Sarg.) (15), and Engelmann spruce (7). During our survey, the fungus was common on all conifer species on most sites.

A black-staining fungus associated with Douglas-fir mortality was found during our survey. The fungus was classified tentatively as a species of *Verticicladiella* based on characteristic conidiophore structure and sympodial production of conidia. It was the only potential root pathogen found on certain trees infested with *D. pseudotsugae*. If the fungus is pathogenic, this is the first report of a black stain root disease on Douglas-fir in the southern Rocky Mountains. *Verticicladiella wagenerii* is an important root pathogen of pinyon in Colorado (12, 18). The fungus is also important on Douglas-fir in California (1, 21), Oregon (4, 5), Idaho (22), and Washington (4). Additional work is required to determine the species identification, distribution, and potential importance of this black stain root fungus on Douglas-fir in Colorado.

Stumps provide infection courts and food bases for the buildup of certain root pathogens such as *F. annosus* and *A. mellea* (23, 24). We found that stumps were adjacent to most white fir infected with *F. annosus*. However, certain *F. annosus*-infected trees and many *A. mellea*-infected subalpine fir were in uncut stands. Additional research is needed on the epidemiology of these root pathogens, particularly regarding the role of stumps in disease development on true fir.

In the past, causes of most forest tree diseases have been attributed to a single pathogen. However, we found mortality centers which had both *F. annosus* and *A. mellea* on the same tree. *Fomes annosus* was often found colonizing the root collar, whereas *A. mellea* was located distal to this colonization on lateral roots. Similar associations have been previously noted (3, Goheen and Filip, *unpublished*). Most of these trees were also infested with bark beetles and blue stain fungi. Therefore, tree mortality appears to be a complex process.

This survey provided general information on root disease-insect complexes within mixed-conifer and spruce-fir stands on four National Forests in Colorado. This preliminary information may be useful for future evaluations to assess root disease impact in the Region. Additional studies should attempt to quantify the distribution of mortality centers within the Region and assess growth loss and mortality caused by root disease-insect complexes.

LITERATURE CITED

1. COBB, F. W., JR. and W. D. PLATT. 1967. Pathogenicity of Verticicladiella wagenerii to Douglas-fir. Phytopathology 57:998-999.

2. FERRELL, G. T. and R. S. SMITH, JR. 1976. Indicators of Fomes annosus root decay and bark beetle susceptibility in sapling white fir. For. Sci. 22:365-369.

3. FILIP, G. M. 1979. Root disease in Douglas-fir plantations is associated with infected stumps. Plant Dis. Reptr. 63:580-583.

4. GOHEEN, D. J. and E. M. HANSEN. 1978. Black stain root disease in Oregon and Washington. Plant Dis. Reptr. 62:1098-1102.

5. HANSEN, E. M. 1978. Incidence of Verticicladiella wagenerii and Phellinus weirii in Douglas-fir adjacent to and away from roads in western Oregon. Plant Dis. Reptr. 62:179-181.

6. HERTERT, H. D., D. L. MILLER, and A. D. PARTRIDGE. 1975. Interaction of bark beetles (Coleoptera:Scolytidae) and root-rot pathogens in Grand fir in Northern Idaho. Can. Entomol. 197:899-904.

7. HINDS, T. E. and F. G. HAWKSWORTH. 1966. Indicators and associated decay of Engelmann spruce in Colorado. USDA For. Serv., Rocky Mt. For. and Range Exp. Sta. Res. Paper RM-25. 15 p.

8. HINDS, T. E., F. G. HAWKSWORTH, and R. W. DAVIDSON. 1960. Decay of subalpine fir in Colorado. USDA For. Serv. Rocky Mt. For. and Range Exp. Sta. Res. Paper RM-51. 13 p.

9. JAMES, R. L. 1979. Fomes annosus on white fir in Colorado. Plant Dis. Reptr. 63:129-130.

10. JAMES, R. L. and L. S. GILLMAN. 1979. Fomes annosus on white fir in Colorado. USDA For. Serv. For. Insect and Dis. Mgmt. Rocky Mt. Region. Tech. Rept. R2-17, 9 p.

11. JAMES, R. L. and L. S. GILLMAN. 1980. Root disease surveys of selected managed conifer stands on the Routt, Gunnison, and White River National Forests in Colorado. USDA For. Serv. For. Insect and Dis. Mgmt. Rocky Mt. Region. Bio. Eval. R2-80-2, 20 p.

12. JAMES, R. L. and C. K. LISTER. 1978. Insect and disease conditions of pinyon pine and Utah juniper in Mesa Verde National Park, Colorado. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Bio. Eval. R2-78-4, 16 p.

13. JOHNSON, D. W. and F. G. HAWKSWORTH. 1977. Shoestring root rot in a lodgepole pine stand. Poudre Ranger District, Arapaho and Roosevelt National Forests. USDA For. Serv., State and Private Forestry. Rocky Mt. Region. Bio. Eval. R2-77-22. 4 p.

14. JOHNSON, D. W. and R. L. JAMES. 1978. Tree hazards in recreation sites -- recognition and reduction. USDA For. Serv. For. Insect and Dis. Mgmt. Rocky Mt. Region. Tech. Rept. R2-1. 17 p.

15. JOHNSON, D. W., T. D. LANDIS, and L. S. GILLMAN. 1976. Rocky Mountain juniper, a new host of Armillariella mellea in Colorado. Plant Dis. Reptr. 60:886.

16. JOHNSON, D. W., T. D. LANDIS, and L. S. GILLMAN. 1976. Shoestring root rot of pinyon-juniper stands. San Isabel National Forest, BLM, State and Private Lands. USDA For. Serv., State and Private Forestry, Rocky Mt. Region, Bio. Eval. R2-76-14. 4 p.

17. LANE, B. B. and D. J. GOHEEN. 1979. Incidence of root disease in bark beetle-infested eastern Oregon and Washington true firs. Plant Dis. Reptr. 63:262-266.

18. LANDIS, T. D. and L. B. HELBURG. 1976. The distribution and ecology of black stain root disease. Plant Dis. Reptr. 60:713-717.

19. MIELKE, J. L. and R. W. DAVIDSON. 1947. Notes on some western wood-decay fungi. Plant Dis. Reptr. 31:27.

20. MILLER, D. L. and A. D. PARTRIDGE. 1974. Root-rot indicators in grand fir. Plant Dis. Reptr. 58:275-276.

21. MILLER, D. R. and E. I. VEIRS. 1968. Verticicladiella wagenerii found on Douglas-fir in El Dorado County, California. Plant Dis. Reptr. 52:393.

22. PARTRIDGE, A. D. and D. L. MILLER. 1972. Bark beetles and root rots related in Idaho conifers. Plant Dis. Reptr. 56:498-500.

23. PIELOU, E. C. 1965. The spread of disease in patchily-infected forest stands. For. Sci. 11:18-26.

24. RISHBETH, J. 1950. Observations on the biology of Fomes annosus, with particular reference to East Anglian pine plantations. II. Spore production, stump infection, and saprophytic activity in stumps. Ann. Bot. 15:1-22.

25. SHOPE, P. F. 1931. The Polyporaceae of Colorado. Annals of the Missouri Botanical Garden 18:287-456.

26. TEGETHOFF, A. C. 1973. Known distribution of Fomes annosus in the Intermountain Region. Plant Dis. Reptr. 57:407-410.

27. WEISS, M. J. and J. W. RIFFLE. 1971. Armillaria root rot in a ponderosa pine plantation in New Mexico. Plant Dis. Reptr. 55:823-824.

28. WILLIAMS, R. E. 1971. The root rot problem in the Northern Region. USDA For. Serv., State and Private Forestry, Northern Region, Insect and Dis. Rept. 71-43. 7 p.

APPENDIX

Selected roads and approximate mileage surveyed for characterization of conifer mortality. (mileage in parentheses)

I. San Isabel National Forest (123.8)

1. San Carlos Ranger District (119.6)

A. North Portion (Wet Mountains) (97.1)

(1) Oak Creek Road (5.0)
(2) Highway 96 (6.7)
(3) Forest Road 306 (9.1)
(4) Forest Road 307 (6.6)
(5) Highway 165 (15.3)
(6) Highway 76 (Simonson Meadow) (7.1)
(7) Forest Road 317 (1.2)
(8) Forest Road 308 (1.4)
(9) Davenport PG Road (3.5)
(10) Forest Road 400 (8.9)
(11) Forest Road 403 (15.9)
(12) Forest Road 404 (4.4)
(13) Forest Road 405 (12.0)

B. South Portion (Spanish Peaks) (22.5)

(1) Highway 12 (6.6)
(2) Forest Road 410 (2.6)
(3) Forest Road 413 (4.7)
(4) Forest Road 415 (5.6)
(5) Forest Road 411 (3.0)

2. Salida Ranger District (4.2)

A. Forest Road 300 (Lake Creek) (1.3)
B. Forest Road 301 (Hermit Lake) (3.9)

II. Rio Grande National Forest (197.9)

1. Conejos Ranger District (48.8)

A. Highway 17 (24.4)
B. Forest Road 103 (8.3)
C. Forest Road 121 (2.1)
D. Forest Road 250 (14.0)

2. Alamosa Ranger District (28.7)

   A. Forest Road 250 (25.2)
   B. Forest Road 330 (3.5)

3. Del Norte Ranger District (113.3)

   A. Highway 160 (9.3)
   B. Forest Road 330 (12.7)
   C. Forest Road 329 (6.6)
   D. Forest Road 332 (4.0)
   E. Forest Road 350 (9.4)
   F. Forest Road 345 (5.2)
   G. Forest Road 359 (5.5)
   H. Forest Road 430 (1.2)
   I. Forest Road 610 (8.4)
   J. Forest Road 612 (12.6)
   K. Forest Road 630 (14.4)
   L. Forest Road 650 (24.0)

4. Saguache Ranger District

   A. Highway 14 (5.9)
   B. Forest Road 950 (1.2)

III. San Juan National Forest (138.5)

1. Pagosa Ranger District (39.3)

   A. Highway 84 (2.3)
   B. Turkey Creek Road (1.4)
   C. Forest Road 657 (11.6)
   D. Forest Road 024 (6.2)
   E. Forest Road 666 (4.8)
   F. Forest Road 665 (9.5)
   G. Forest Road 037 (3.5)

2. Piedra Ranger District (39.2)

   A. Forest Road 631 (26.4)
   B. Forest Road 634 (5.4)
   C. Forest Road 640 (5.0)
   D. Forest Road 645 (2.4)

3. Pine Ranger District (27.9)

   A. Forest Road 135 (11.0)
   B. Forest Road 597 (6.3)
   C. Forest Road 602 (2.2)
   D. Forest Road 603 (4.2)
   E. Forest Road 724 (4.2)

4. Animas Ranger District (18.9)

   A. Highway 550 (14.8)
   B. Forest Road 578 (1.9)
   C. Forest Road 581 (2.2)

5. Dolores Ranger District (13.2)

   A. Forest Road 545 (13.2)

IV. Grand Mesa National Forest

1. Collbran Ranger District (17.0)

   A. Forest Road 121 (4.2)
   B. Highway 65 (12.8)